



## ***Army Transformation to the Future Force...A Race for Speed and Precision***

***7<sup>th</sup> Annual High Performance Embedded Computing Workshop  
Lincoln Lab/MIT***



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# ***Purpose***

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- ***Describe Army's vision of the Future Force***
- ***Address Army needs and challenges in High Performance Embedded Computing (HPEC) to enable Transformation to the Future Force***



# Future Force for Full Spectrum of Missions

## Environmental Complexity

High  
Urban



Open  
rolling  
terrain

Low

Stability and Support  
Operations

Small Scale  
Contingencies

Major Theater War

Spectrum of Conflict

## Increased strategic responsiveness

- ✈ Brigade in 96 hrs;  
Division in 120 hrs;  
Five Divisions in 30 days
- ✈ Fight immediately upon arrival
- ✈ Simultaneous air and sea lift

**Render Previous Ways of Warfighting Obsolete**





# Seeking A Revolution in Capabilities ... Smaller, Smarter, Lighter & Faster

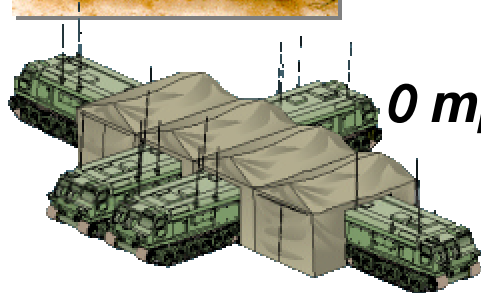
## Today



~100 lb.  
load

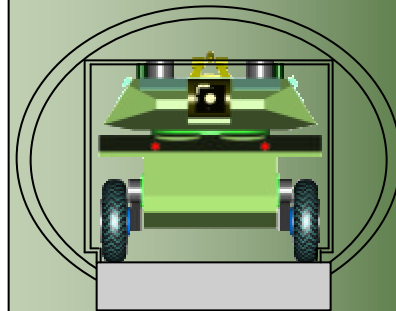


70+  
tons



0 mph

Fit the C-130  
“Crucible”



Implement  
“System of Systems”

## Future Force

< 40 lb.  
effective  
load



< 20  
tons



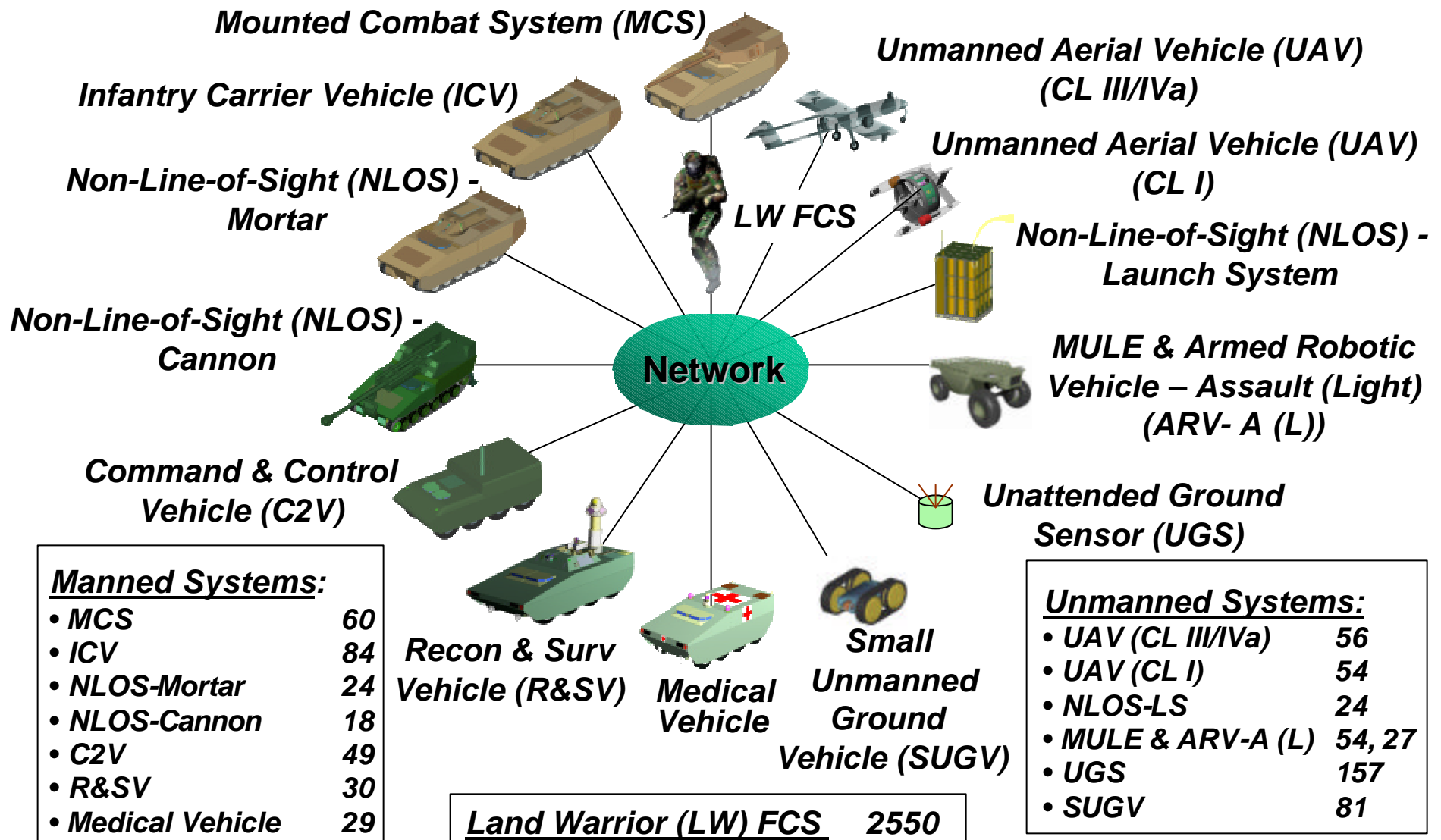
> 40  
mph



**S&T Mission -- Accelerating the Pace of Army Transformation**



# Future Combat Systems (FCS) Maneuver Unit of Action (Brigade Equivalent)





# ***Unit of Action Networked Battle Command***

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- ***Sensors – Information gatherers***
- ***Network Architecture – Information management (processing, routing, dissemination)***
- ***Nodes or platforms (soldiers, ground vehicles, aerial vehicles) – Information receivers, gatherers and users (FCS ~ 3300)***
- ***Shooters – Information receivers and users***

***See First, Understand First, Act First, Finish Decisively***



# ***FCS Key HPEC Challenges***

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- ***Network-centric/Collaboration-centric***
  - ***Local HPEC capabilities to manage the complexity of large amounts of data and information***
  - ***HPEC will enable local nodes to perform complex analysis and data management functions with reduced use of bandwidth***
- ***Robotics integrated into force***
  - ***Real time scene understanding for maneuver and threat analysis***
  - ***Real time RISTA from multiple sensors and sensing modalities***
- ***Increased reliance on extended range engagement***
  - ***HPEC crucial for smart munitions – accurate target ID***
  - ***Wide range of distributed sensors, each needing HPEC***
- ***Capable of air-mobile operations - DoD strategic and tactical lift***
  - ***New smaller sized force elements require small embedded processors to meet demanding computing requirements***





# Objective Force Warrior (OFW)

- ***Integrated Combat Suit***
- ***Head Borne Vision Enhancement***
- ***Physiological Status Monitoring***
- ***Personal Navigation***
- ***Robotic Mule***
- ***Situational Awareness***
  - ***Networking Digital Radio***
  - ***Warrior Team collaboration***
  - ***Horizontal data fusion***



**Micro  
UAV**



**Robotic  
Mule**



# ***OFW Key HPEC Challenges***

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- ***Real time situational awareness***
  - ***Connection and exploitation of information from FCS network***
  - ***Access to Common Operating Picture***
  - ***Vertical/horizontal position/navigation***
  - ***Status of physiological readiness and vital signs***
  - ***Two-way language translation***
- ***Embedded training***
  - ***Planning and rehearsal of complex missions***
  - ***Immediate access to Tactics, Techniques and Procedures (TTPs)***



***Low power HPEC is an essential OFW need***



# ***HPEC Challenge: Communication Functions***


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- ***Network may be source of “surprise” computational problems and system congestion / bottlenecks***
- ***Will be the largest, most ad hoc, dynamic and mobile Unit of Action network ever deployed***
  - ***A ground traffic control system integrated with an air traffic control system that will work in all environments and conditions***
  - ***Mix of SATCOM, platform and soldier radio networks***
  - ***Rapidly formed and broken links rates, i.e., “chaotic network”***
- ***Routing and network management may require:***
  - ***Active network technology***
  - ***Very advanced routing methods – heavy computation***
- ***Demand for fully distributed computing***
- ***Power-aware routing, low power computing***



# ***HPEC Challenge: Communications Security***

- ***HPEC can assist in data encryption***
- ***Process is very complex, i.e., multilevel security, and computationally intensive especially for authentication.***
- ***Challenge is striking a balance between security and performance, interoperability, reliability, . . .***
- ***Main processing challenge is complexity of decoding encryption techniques used in authentication***

<b><i>Symmetric Encryption Key Size</i></b>	<b><i>ECC Key Size</i></b>	<b><i>RSA Key Size</i></b>	<b><i>Computational Complexity</i></b>
56	112	512	 <b><i>Increases with key size</i></b>
80	160	1024	
112	224	2048	
128	256	3072	
192	384	7680	
256	512	15360	



## ***HPEC Challenge: Aided / Automatic Target Recognition***

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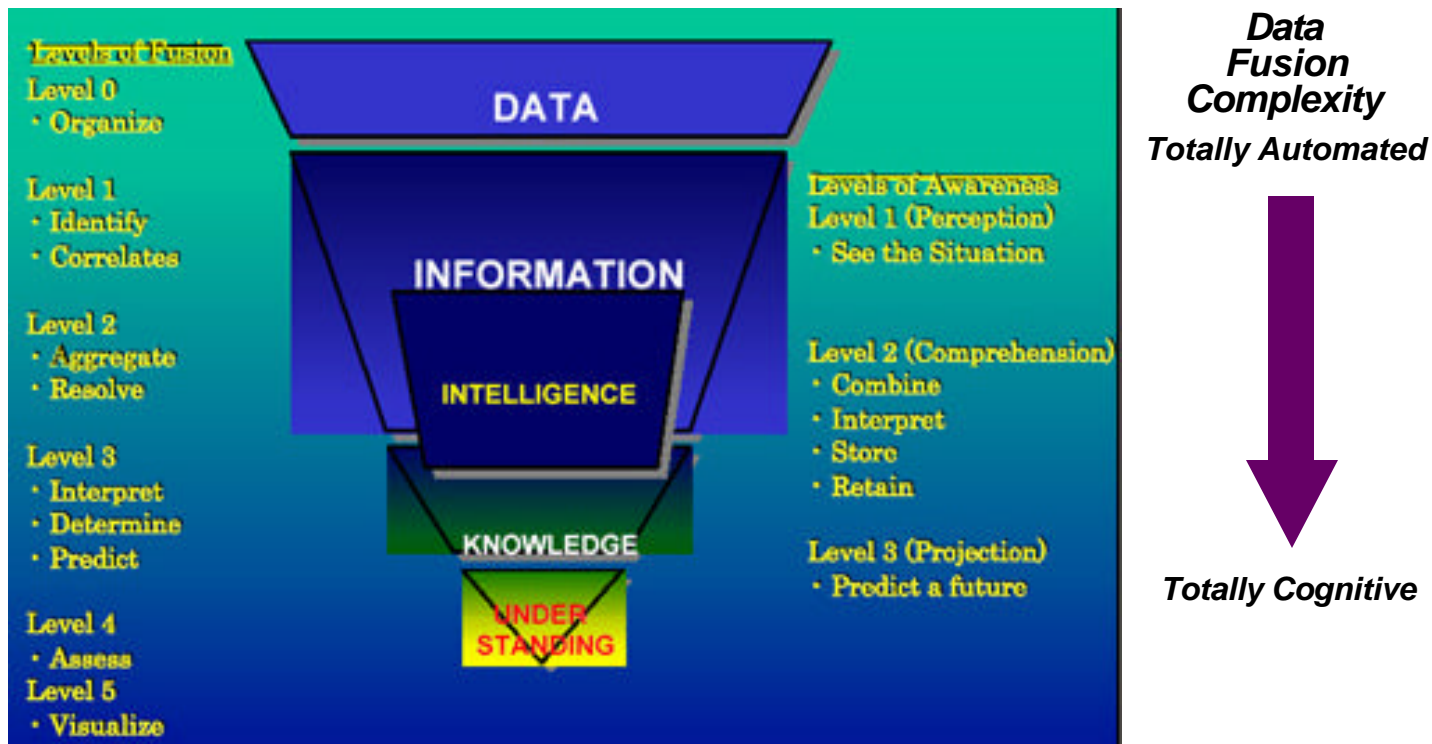
- ***Typical ATR systems analyze a digital representation of a scene and locate/identify objects of interest***
- ***While conceptually simple, ATR has extremely demanding I/O and computational requirements***
- ***Image data are large, can be generated in real-time, and must be processed quickly so that results remain relevant in a dynamic environment***
- ***Future Force ATR will incorporate more than one sensor and use more data from other sources***





# HPEC Challenge: Data Fusion

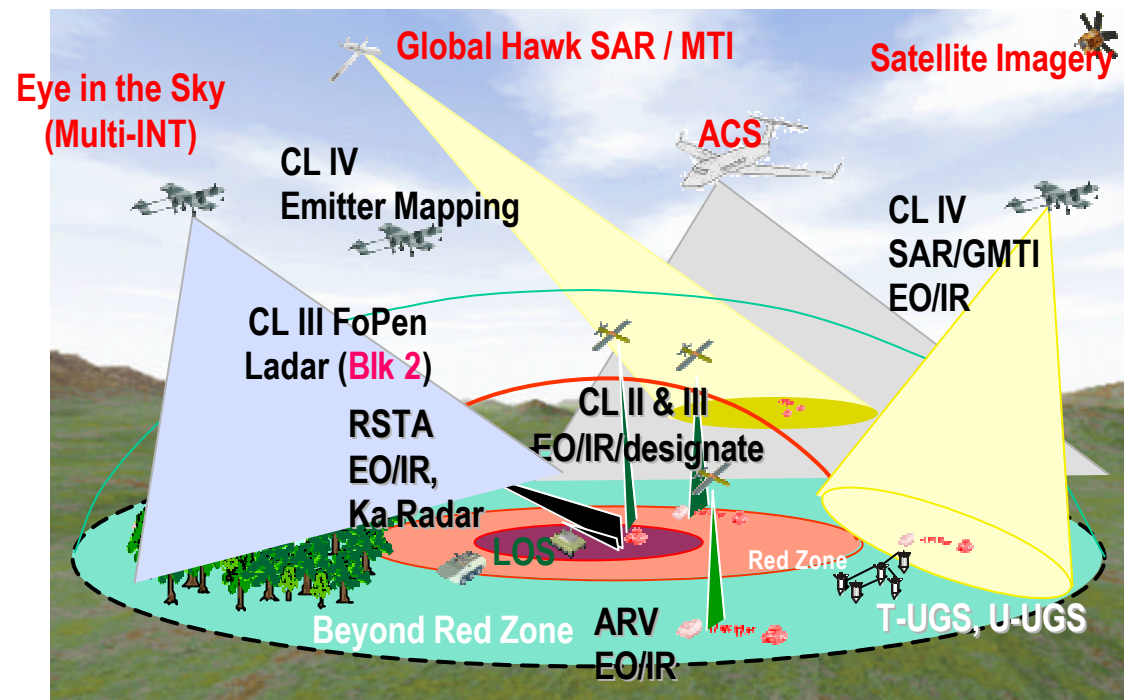
- ***Functions needed for multi-source fusion***
- ***Distributed, real time fusion is needed to minimize command center message inundation***
- ***FCS will increase the volume and complexity of data – more local fusion is needed***





## Army S&T Program That Uses HPEC “Eye in the Sky”

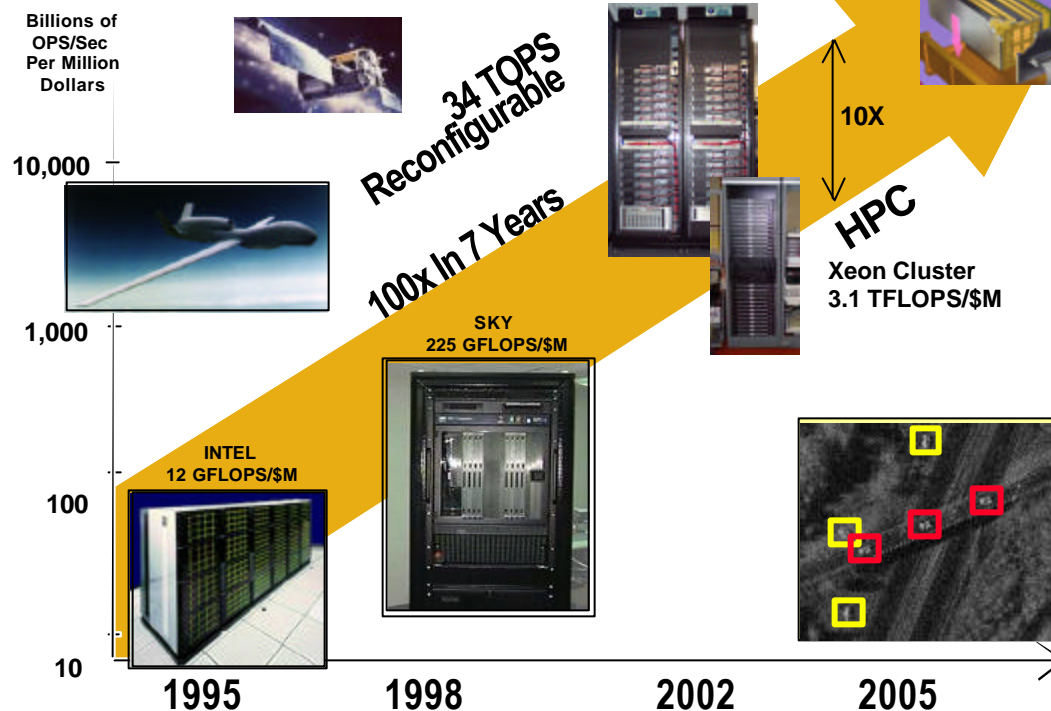
- **Demonstrate onboard automated payload management functions to facilitate tasking and cross-cueing of sensors**
- **Onboard, autonomous sensor management and data fusion**
- **Software to integrate RF Tags SA data into the COP for Blue Force tracking**
- **Multiple Sensors**
  - Radars (GMTI, SAR, GPEN, FOPEN)
  - EO/IR
  - Hyper-Spectral
  - Electronic Support Measures
  - LADAR
- **Integrated on a Class IVA UAV**





# HPEC Challenge: Affordability

## Exponentially Improving HPEC Affordability Transitioned to DoD Users



**Projection:**  
**2007: 60 trillion flops/\$M**  
**2010: 360 trillion flops/\$M**

## CHALLENGE

- **Develop and incorporate the most affordable embedded information technology available**

## APPROACH

- **Leverage commercial investments in computer architectures**
- **Develop portable embedded DoD applications using middleware standards**
- **Leverage DARPA and other DoD efforts in emerging architectures**

Source: Dr. Rich Linderman, RADC



# Trend in Computer Size

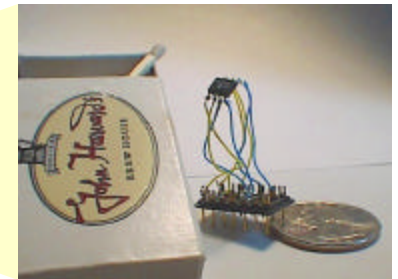
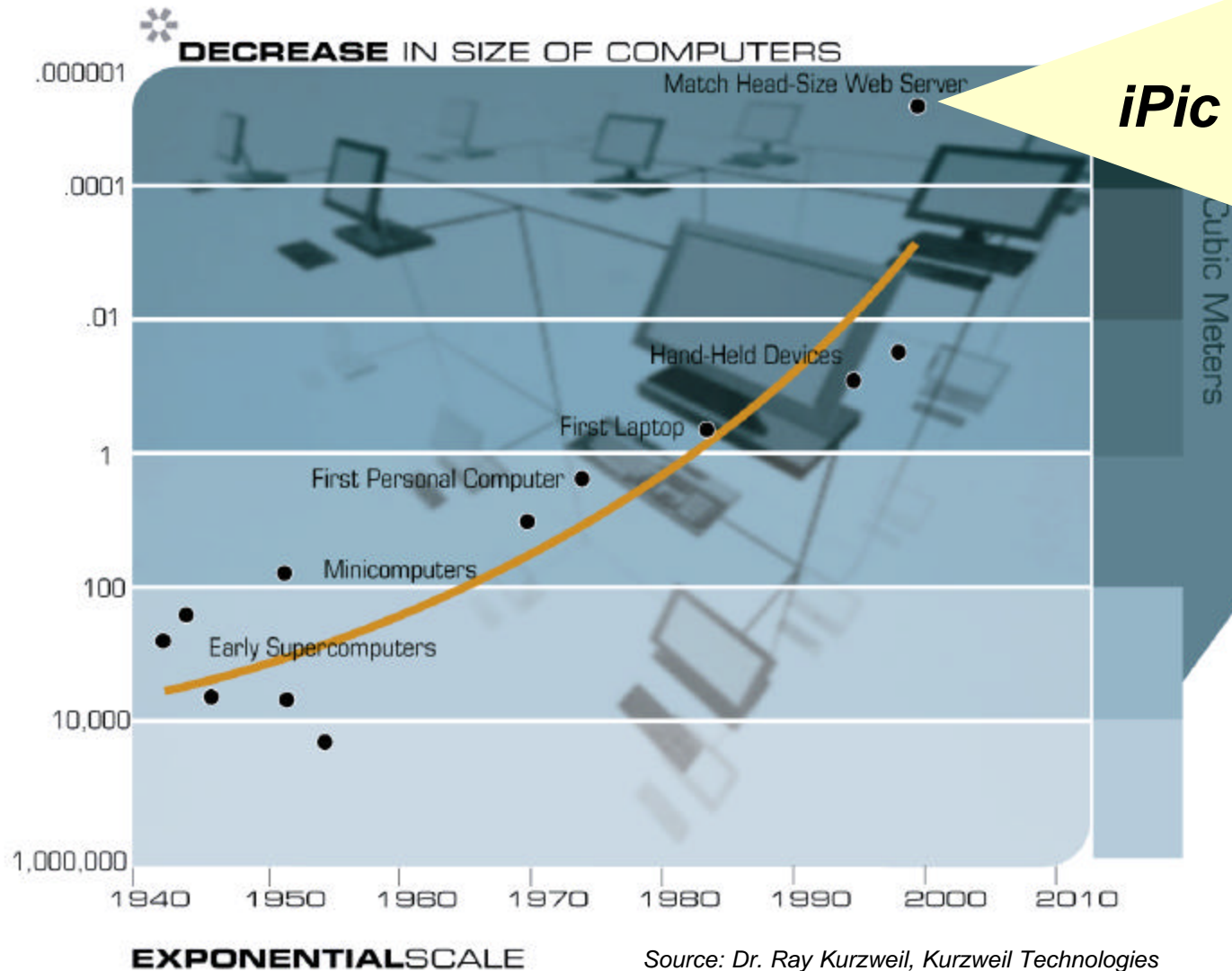
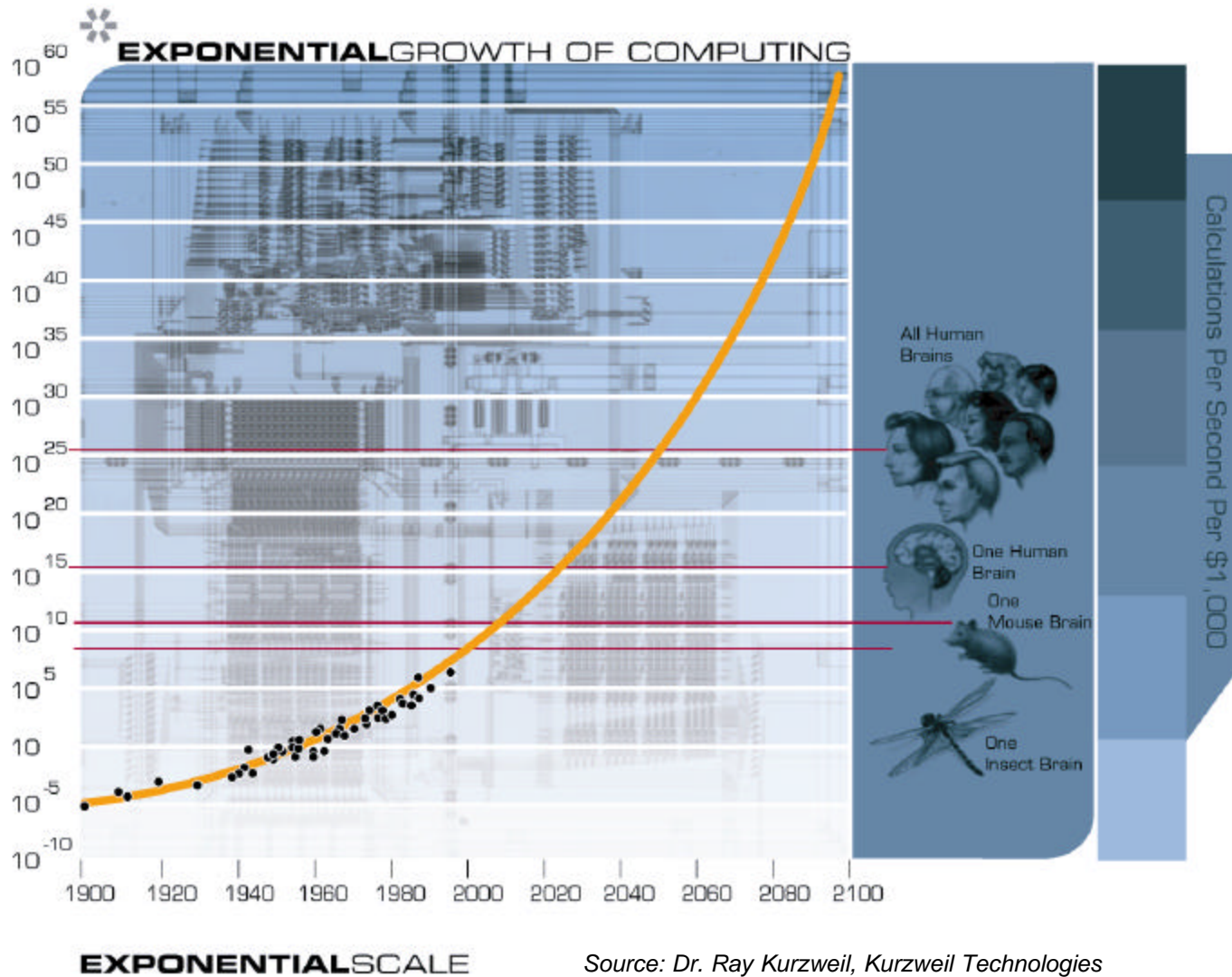


Photo courtesy of Cris Pedregal-Martin  
<http://www-ccs.cs.umass.edu/~shri/iPic.html>





# Trend in Growth of Computing







# Summary

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- ***The Army's Future Force will have a critical need for HPEC technologies throughout its system of systems***
  - ***Autonomous sensing and sensor fusion***
  - ***Complex communications tasks***
- ***The acute Army challenges for HPEC are cost, power consumption and physical size***
- ***The Army is looking to academia and industry for advances in HPEC to enable its vision of the Future Force***

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